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Municipal Sludge Management

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ENVIRONMENTAL FACTORS; TECHNICAL BULLETIN

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ENVIRONMENTAL PROTECTION AGENCY

[FRL 810-7]

MUNICIPAL SLUDGE MANAGEMENT

Environmental Factors; Technical Bulletin

On June 3, 1976, in the FEDERAL REGISTER (41 FR 22532), the Environmental Protection Agency published for public comment a proposed technical bulletin, "Municipal Sludge Management: Environmental Factors." The Bulletin has been prepared to assist EPA Regional Administrators in evaluating grant applications for construction of publicly owned treatment works under Section 203(a) of the Federal Water Pollution Act as amended. It also provides designers, municipal engineers and others with information for selecting a sludge management option. The Bulletin addresses only factors important to the environmental acceptability of a particular sludge management option and does so in a general manner to allow maximum flexibility.

Written comments on the proposed Technical Bulletin were invited and received from interested parties. EPA has carefully considered all comments received. All written comments are on file with the Agency, and are available for examination at the Municipal Construction Division, Office of Water Program Operations.

Many of the comments received clearly expressed concerns over the need for regulations, criteria and detailed guidelines to provide better control of sludge disposal and utilization activities. Although this Bulletin will exercise some control over the design of sludge management systems, it does not address in detail the control of operating systems. Efforts pursuant to the recently passed Resource Conservation and Recovery Act of 1976 (Pub. L. 94-580) are underway to develop specific criteria and guidelines for sludge management activities.

Comments were received from a wide variety of sources (Federal agencies, State regulatory agencies, environmental groups, municipalities/counties/cities, consultants, university extension and research groups, special interest groups and the general public). These comments indicated both support for and opposition to a number of points made in the proposed Technical Bulletin. Conflicting points of view were often noted among comments received on a particular topic, even when received from the same type of reviewer. In many cases, agreement was indicated by numerous commenters who favored or supported a certain position. Modifications were made to the document wherever there was clear and strong support for change.

The principal comments received and the responses to them are summarized below:

(a) Several comments requested that public hearings be held prior to final publication of the Technical Bulletin. Numerous versions of the proposed document have been extensively reviewed and the comments received were carefully considered. The major issues raised were generally the same issues that were identified during the early efforts to develop this document and center on regulatory concerns. The need for specific criteria and guidelines for the control of land disposal and utilization practices was the major concern expressed in the comments. Criteria for State regulatory programs for the control of solid waste activities, including municipal sludge management, are being developed as part of implementation of the Resource Conservation and Recovery Act of 1976 (Pub. L. 94-580). Public Hearings will be conducted as part of efforts to establish criteria and guidelines under that Act.

(b) Many comments were received that indicated a need to clarify the roles of the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA) in the development and review of facility plans addressing sludge management. The detailed monitoring, review and approval activities by USDA and FDA for certain projects as indicated in the proposed document could lead to excessive manpower and funding requirements for these Agencies. The final version recognizes FDA as the agency which should establish recommended acceptable levels of various contaminants in human foods and animal feeds. In addition to indicating the availability of USDA assistance to municipalities, the Bulletin encourages USDA to continue to develop and provide site-specific recommendations on the best agricultural practices for use of municipal sewage sludge by farmers on privately owned lands. The objectives of such recommendations are to minimize or eliminate monitoring requirements on the farm while protecting farmland for future agricultural use, maintaining normal productivity, and assuring continued farm income. Technical assistance is a major role and will be available from FDA, various USDA extension and research offices, as well as EPA and the State Agricultural Experiment Stations.

(c) Numerous comments were received regarding the need for establishing allowable levels for heavy metals and other contaminants in sludges applied to the land. This document is not intended to be regulatory in nature, but rather to provide information on items to be considered in evaluating construction grant applications. More specific guidance on acceptable levels of contaminant additions to agricultural land from solid waste (including sludge) are planned to be developed and published under the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (Pub. L. 94-580).

In an effort to provide the most current state-of-the-art information available on the potential effects on agricultural crops and animals by heavy metals in sewage sludges applied to cropland, EPA has recently published a report titled "Application of Sewage Sludge to Cropland: Appraisal of Potential Hazards of the Heavy Metals to Plants and Animals" prepared by the Council for Agricultural Science and Technology (EPA 430/9-76-013; November 1976). This report and others that are planned for publication in the near future will provide in-depth presentations of available information on topics of major interest and concern related to municipal sewage sludge management.

The revised Bulletin recommends that adequate testing of the sludge be undertaken to provide the user with a basis for designing and operating the system and for developing future control mechanisms. It recommends that all sludges be analyzed to determine the range of levels of heavy metals (especially Cd, Zn, Mo, Ni and Cu), persistent organic compounds (such as chlorinated pesticides, and PCB's), and other chemical or biological contaminants of concern whenever land application of sludge is proposed.

(d) Numerous comments addressed the section on "Projects of Minimal Concern." In response to these comments and other factors, this section has been rewritten to only address demonstration projects. For demonstration projects where significant resources and manpower are available for control and monitoring, it is indicated that recommendations within the Bulletin may be exceeded in an effort to investigate new approaches for sludge management. General guidance for "dedicated" utilization or disposal sites is provided in other sections.

(e) Numerous comments expressed the need for additional detailed information to be included in the Bulletin covering each utilization and disposal option. The final Bulletin has been maintained as short and precise as possible while providing general guidance to the Construction Grants Program on those environmental factors to consider when reviewing proposed municipal sewage sludge management projects. It was not written as a regulatory document or design manual. Current pertinent regulations are either cited or referenced. Criteria and guidelines for solid waste (including sludge) disposal onto land which are planned to be developed and issued under Pub. L. 94-580 should provide more specific guidance. Detailed reports are being planned to supplement the Bulletin and provide the detailed data base and information on other topics of concern to municipal sludge management.

(f) Clearly conflicting comments were received regarding the general tone of the proposed bulletin towards land application of municipal sewage sludge. Many comments indicated that the intent of the Bulletin was far too restrictive on agricultural use of sludge. Others felt that the coverage of cropland uses was too liberal. Both support of and opposition to the application of municipal

sludge to parklands, disturbed land and forests were indicated by different commenters. The revised document attempts to encourage the beneficial utilization of municipal sludge as a resource, and cites experience as guidance in evaluating construction grant applications on sludge uitilization procedures that have experienced no known environmental problems.

(g) Numerous comments were received concerning the intent of this document towards supporting the utilization or disposal of municipal sludges. Since land application of many sludges can be beneficial to the soil and crops, this method would be preferable to sludge disposal practices that preclude these beneficial effects. Of course, these practices should be implemented in a manner that is also environmentally acceptable. The guidance given in the Bulletin concerning the utilization of sludge by land application is intended to provide maximum flexibility to minimize possible environmental problems, since the available information is still limited.

(h) Comments received in regard to the monitoring requirements of the proposed document generally favored the need for some monitoring of sludge disposal and utilization projects, but disagreed on the extent to which monitoring should be required. The revised document recommends the development of an adequate baseline analysis for specific heavy metals and persistent organic compounds in the sludge to provide the basis for additional site-specific monitoring requirements. The monitoring plan developed for a land application project should be designed for the local site conditions, project operation and sludge analysis.

(i) Numerous comments were received regarding the importance of adequate pretreatment requirements to control industrial discharges of contaminants into publicly-owned sewage treatment works that may eventually create sludge management problems. The Bulletin strongly emphasizes the importance of pretreatment as a means of reducing the contaminant levels in sludges, while not specifically addressing possible pretreatment actions. The Agency has embarked on an accelerated program under Pub. L. 92–500 to develop (1) pretreatment standards for the most significant polluting industries, and (2) standards pertaining to the discharge of designated toxic pollutants. Additionally, the Agency has recently issued revised pretreatment guidelines to assist municipalities in developing local pretreatment requirements.

(j) A number of comments were received regarding the determination of appropriate application rates for sludges applied to the land. Most agreed with the approach taken in the proposed document calling for maximum application rates to be based upon crop nitrogen needs and groundwater concerns. Therefore, this approach was maintained in the final document.

(k) Numerous comments were received indicating a need for defining, or at least clarifying, the meaning of such terms as "stabilization," "food chain and non-food chain crops," "utilization and disposal," "agricultural and non-agricultural uses," "high/average/low sludge quality" and "application rates." Efforts were made in the final bulletin to provide definitions or at least clear indications as to the intended meaning of such terms. In addition, an appendix is included that provides typical values observed for various contaminants in municipal sludge under different circumstances.

(l) Numerous comments were directed at the technologies available to meet the stabilization requirements of various sludge management practices. It was generally agreed that the stabilization discussion in the proposed document was too restrictive. In the revised Bulletin, efforts were taken to establish the need for stabilization, but not to provide a complete list or details of available stabilization technologies. The reader should refer to the "Process Design Manual for Sludge Treatment and Disposal" (EPA 625/1–74–006; October 1974) for more specific information on sludge stabilization techniques.

(m) Several comments were received indicating the need for clearer guidance on when additional pathogen reduction techniques are required and what pathogens need to be controlled. The final Bulletin indicates that under certain site-specific project conditions, pathogen reduction list of methods that have been used to further reduce pathogen levels in sludge. Since the conditions that would require the need for additional pathogen reduction are generally site- or project-specific, no attempt was made to identify when this would be required, except with regard to the production of directly consumed human foods.

(n) Numerous comments were received regarding the restrictions recommended for the protection of food products and agricultural land. Most, but not all, reviewers agreed that this section was too restrictive as presented in the proposed document. Many reviewers strongly opposed the restrictions requiring (1) three years after sludge application before human food crops may be grown to be eaten raw, and (2) the sludge applied to be negative for *Salmonella* and *Ascaris* ova if applied to soils where crops are grown which are normally cooked in the home before consumption, but marketed without being subjected to a process which is lethal to pathogenic microorganisms and pathogens.

The revised document encourages the use of stabilization methods together with additional precautions to minimize pathogen, parasite and viral content of sludge used in agriculture. Application methods that prevent direct contact of the sludge with the portion of the crop to be consumed are encouraged. The Bulletin also recommends that projects conform to any limitations for crop quality (both human and animal feeds) established by FDA, USDA or State agencies.

The Technical Bulletin exclusive of the cited appendices is printed below. A copy of the complete Bulletin, including appendices, may be obtained by writing to the General Services Administration (8FFS), Centralized Mailing Lists Services, Bldg. 41, Denver Federal Center, Denver, Colo. 80225. Please indicate the title of the publication and the document number: MCD–28 (EPA 430/9–77–004).

Dated: October 26, 1977.

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TECHNICAL BULLETIN

MUNICIPAL SLUDGE MANAGEMENT:
ENVIRONMENTAL FACTORS

CONSTRUCTION GRANTS PROGRAM, OFFICE OF WATER PROGRAM OPERATIONS, U.S. ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, D.C. 20460

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Appendix V—"National Emissions Standards for Hazardous Air Pollutants," Subpart E—National Emission Standard for Mercury, 40 CFR 61.50.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

TECHNICAL BULLETIN

MUNICIPAL SLUDGE MANAGEMENT: ENVIRONMENTAL FACTORS

Foreword

This Technical Bulletin has been prepared to assist Environmental Protection Agency (EPA) Regional Administrators in evaluating grant applications for construction of publicly owned treatment works under section 203(a) of the Federal Water Pollution Control Act as amended. It also provides designers, municipal engineers and others with information on sludge management options.

The Bulletin was developed from the outputs of an Agency workgroup that attempted to prepare an Agency policy statement and guidelines on sludge management. These efforts were undertaken with substantial assistance provided by individuals from the Council on Environmental Quality, the U.S. Department of Agriculture, the Food and Drug Administration, and the Department of the Army.

The relative risks, benefits and costs of various sludge management practices should be thoroughly considered when evaluating potential alternatives for specific projects. While some degree of risk is inherent in any sludge management option, trade-offs among risks, benefits and costs should help direct projects toward the selection of both an environmentally and economically viable utilization or disposal alternative.

The Bulletin addresses only factors important to the environmental acceptability of particular sludge management options and does so in a general manner to allow a maximum flexibility in its interpretation to meet varying Regional needs and site specific factors. It was not written as a regulatory document or design manual. An environmental assessment/environmental impact statement procedure is used to determine the acceptability at a specific site. This procedure is described in EPA's regulations for "Preparation of Environmental Impact Statements" (40 CFR 6, Appendix I).

The cost-effectiveness of a proposed sludge management option is of great importance. Information on the EPA cost-effectiveness program is contained in Appendix I. Detailed information on pretreatment guidelines and regulations, sample collection/preservation/analysis procedures, as well as in-depth reviews of the somewhat controversial potential environmental impacts of land application are or will be covered in additional supporting documents.

While the main body of the Bulletin includes considerable detailed information on land application alternatives, it is not intended to indicate a preference for this or any other sludge management option. The Bulletin emphasizes land application alternatives since no EPA guidance has been issued on this subject in the past. It incorporates existing Agency guidance (and regulations where applicable) on the other major options—incineration, landfill, and ocean disposal—mainly by means of references and appendices. It is important that all of the available options must be considered, including incineration and landfilling as well as land application, to assure that the best alternative, in terms of environmental acceptability, cost-effectiveness, and benefit, is selected.

The requirements of the Act for higher levels of wastewater treatment will result in a substantial increase in the quantity of sludge produced at publicly owned treatment works. Disposition of these sludges is not simple. Methods used in the past are now restricted by specific laws or regulations, or are subject to other constraints in view of new information of environmental significance.

EPA, continuing the work of its predecessor agencies, has been developing environmentally acceptable methods for the management of municipal sludge since the enactment of the first Federal water pollution control laws. The initial phases of the research program were concerned with the characteristics and dewatering properties of primary and secondary sludge because of the need to dewater sludge before its ultimate disposal. The current program emphasis has shifted toward development of improved technology for returning the sludges to the environment in an acceptable manner. Also, the Agency is requiring new measures, such as source control and pretreatment, which should reduce the heavy metals problem associated with sewage sludges.

The Agency has been aware of the growing sludge disposal problem and the need to verify and expand the technology that is now being utilized. For example, a long-term land application project has been directed at determining the beneficial uses of sludge for strip mine reclamation and for soil enrichment in crop production. These studies have carefully monitored the heavy metals uptake in various forage and grain crops.

A large increase in the amount of sludge generated has occurred with the use of chemical precipitants for nutrient control and the upgrading of secondary treatment facilities. The Agency has been actively developing new technology for solving the problem, including recovery and reuse of the chemical additives.

EPA will continue its broad based research program for municipal wastewater sludge management. Depending on the availability of resources, we will concentrate on demonstration of new technologies which will recycle or reuse resources, reduce energy requirements, or recover residuals contained in sludges.

For example, new technologies are being examined to determine if there are cost-effective methods for producing or recovering marketable products in the processing of sludge. These products may include: metals recovery, simple organic acids, fertilizer bases, soil conditioners, the recovery of process heat, fuels for energy production, and activated carbon.

Health effects research will include investigation into land application, disinfection, composing, and airborne contaminants from incineration. The improved technology for reducing or eliminating pollutant emissions to the environment will be evaluated from a health and ecological effects standpoint. It is also EPA's intent to continue cooperative agreements with local, State, and other Federal agencies.

The Technical Bulletin is based on current knowledge. It will be modified from time to time as additional information becomes available from current and future research, development, and demonstration projects as outlined above. New research, development, and demonstration projects which offer potential for reducing costs or improving technology are encouraged; this includes projects that do not meet the specific recommendations of the bulletin, if there is reason to believe that they will eventually be acceptable. This Bulletin will also be supplemented by a series of detailed technical reports on topics of major concern. The first: "Application of Sewage Sludge to Cropland: Appraisal of Potential Hazards of the Heavy Metals to Plants and Animals" (EPA 430 9/76-013) is already available. (A copy of this report can be obtained by writing to the General Services Administration (8 FFS), Centralized Mailing Lists Services, Bldg. 41, Denver Federal Center, Denver, Colo. 80225. Please indicate the title of the publication and MCD-33.)

It is believed that the techniques discussed in this bulletin can be environmentally acceptable if properly designed, constructed and managed. It must be well understood that proper operation, maintenance, and monitoring of any sludge management system are essential. The operators of such systems must clearly demonstrate the managerial capability and resources necessary to achieve and maintain the expected performance on a continuing basis.

The guidance and recommendations in this technical bulletin are subject to revision based on future experience in the field. All users are encouraged to submit suggested revisions and information to the Director of the Municipal Construction Division (WH-547), Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, D.C. 20460.

Dated: October 26, 1977.

THOMAS JORLING,
Assistant Administrator,
Water and Hazardous Materials.

U.S. ENVIRONMENTAL PROTECTION AGENCY

TECHNICAL BULLETIN

MUNICIPAL SLUDGE MANAGEMENT: ENVIRONMENTAL FACTORS

Chapter I

Introduction

1-1. The treatment of wastewaters for pollutant removal produces not only relatively clean water for discharge, but also a significant quantity of residue material. For domestic sewage, treated in publicly owned plants, this residue is essentially organic in nature, although measurable quantities of metals, minerals, and other compounds are also invariably present. The residue may also contain pathogenic organisms which survive the wastewater treatment process. Where industrial wastewaters are treated together with domestic sewage, the potential for addi-

tional materials of concern in the resulting sludge is increased.

1–2. Depending upon the composition of the wastewater treatment plant sludge and the quantity involved, disposal of this residue material can have a significant impact on the environment. It is essential for wastewater treatment installations to consider the proper disposal of treated wastewater, as well as all byproducts and residues such as sludge. The requirements of the Federal Water Pollution Control Act, as amended (Pub. L. 92–500), emphasize the need for environmentally sound means for sludge utilization or disposal. The national requirement under Pub. L. 92–500 for secondary treatment, for example, will result in production of greater quantities of sludge.

1–3. The disposition of wastewater treatment plant sludges is a complex problem. It can affect the quality of air, land, and water, and requires considerations of human health, animal health, plant growth, and protection of ground and surface water from pollution. EPA Regional Administrators must consider all these matters as they evaluate sludge management systems included in the design of publicly owned treatment works for which construction grant applications are made. Despite the still limited information available on the complex issue of sludge utilization and disposal, the need for definition of a baseline of acceptable sludge utilization or disposal practice remains. Such a baseline is planned for development under the authorities of the Resource Conservation and Recovery Act (Pub. L. 94–580).

1–4. For the reasons cited above, a description of items to consider when selecting a specific sludge utilization or disposal alternative are presented in this document. This technical bulletin provides general guidance on the factors to be considered in the environmental assessment and to be used in reviewing the facts of a particular situation. For the utilization and disposal methods discussed no attempt is made to limit the implementation of innovative technologies or to imply that any particular method is optimum for sludge utilization or disposal. The final determination of acceptability should be based on the environmental assessment and, if necessary, the environmental impact statement for a specific project.

1–5. The bulletin is divided into two distinct parts. The first part includes methods in which the sludge is utilized as a resource by land application. The second part describes those methods where a beneficial use is not emphasized. System involving the recovery and utilization of energy or residuals contained in sludges are not specifically covered in this document. Examples of such systems are the production and utilization of digester gas, incinerator gas or steam; recovery and reuse of chemical conditioners; recovery and sale of metals. However, the environmental impacts associated with energy recovery systems would be similar to those identified for the sludge incineration practices covered in this bulletin.

1–6. Methods which may have future promise, but which have not been used in existing facilities, are not included. As these developing technologies are demonstrated in practical use, and as supporting information is obtained, they will be added in updates of this bulletin. Because it is the policy of EPA to encourage and, where possible, assist in the development of new or advanced wastewater treatment procedures, Federal grant funds may be awarded for the construction of sludge utilization or disposal facilities not addressed in the bulletin, provided sufficient information is presented by the grant applicant to determine that these facilities would meet applicable statutory and regulatory requirements and would be environmentally acceptable.

1–7. Proper operation, maintenance, and monitoring of sludge utilization or disposal practices are essential to ensure that adverse environmental effects do not result. Grant applicants must demonstrate that they will have managers, operators, and resources necessary to achieve and maintain the required performance on a continuing basis.

1–8. Efficient energy utilization, conservation and recovery are increasingly critical topics. Full consideration of these factors is necessary in the comparison of alternatives in the selection of a sludge management method.

Chapter II

Land Application of Sludge

2–1. *General.* In order to contribute to energy and resource conservation in wastewater treatment facilities, sludge management technologies which will beneficially recycle or reuse sludges are actively encouraged. Because land application of sludge provides an excellent soil conditioner while conserving and recycling organic matter, nitrogen, phosphorus, and certain essential trace elements, such utilization is encouraged when it is supported by an environmental assessment.

Specifically, the use of stabilized sludge by land application for enhancement of parks and forests and reclamation of poor or damaged terrain should be considered for the utilization of sludge. Application of stabilized sludge to agricultural lands may also be regarded as an environmentally acceptable method of sludge utilization/disposal, but must be examined closely in terms of protection of human health and future land productivity. This is due to the present limited knowledge and uncertainties as to the extent to which this practice could result in the entry of toxic substances into the human food chain and pose a health risk.

Regulations, criteria, and guidelines being developed under the authorities of Pub. L. 92–500, TSCA, RCRA and other recent environmental legislation may impact the future acceptance of various land application practices in various ways. The development of criteria and guidelines under RCRA will define acceptable levels of pollutants for land application of solid wastes. The implementation of the anticipated Agency pretreatment strategy now under development will substantially reduce contaminant concentrations of many municipal wastewater treatment plant sludges (especially cadmium and persistent organics). These efforts should further enhance the acceptability of sludges for agricultural uses. By this emphasis on prevention of future problems, we hope to move toward a goal of waste recovery and recycling.

The environmental concerns associated with the beneficial utilization of sludge by land application practices are discussed at length in the following paragraphs.

2–2. *Information for Project Evaluation.*

2–2.1 *Sludge characteristics.* Sludge from existing plants should be tested to determine nutrient values, heavy metals, and other constituents which may be economically recycled or cause environmental damage (Appendix VII). The type of tests and their scheduling is site specific and dependent on regulatory requirements, the intended use of the sludge, the contaminants likely to be present, and the intended use of the crop if one is grown. For new projects, it will be necessary to estimate the sludge characteristics; the application rates actually used on a project should, however, be based upon actual sludge analyses. Some indication may be available from pilot plant studies, but such studies are rarely conducted at smaller plants.

When sludges are to be applied to land, for beneficial purposes, appropriate non-domestic users of municipal wastewater treatment works should be required to pretreat their wastewaters to minimize the presence of potentially harmful heavy metals and other sludge contaminants from industrial sources. Pretreatment requirements should meet Federal pretreatment standards. (Current pretreatment regulations are covered in 40 CFR Parts 128 and 403. Also, see "Federal Guidelines: State and Local Pretreatment Programs," EPA 430/9–76–017 a, b, c) However, quantities of these materials also may be present in wastewaters usually considered of non-industrial origin.

2–2.2 *Site soils.* Soils receiving sludge for agricultural purposes, should be tested for phosphorus, potassium, pH, and heavy metals. There should also be knowledge of the approximate soil cation exchange capacity. Soils data and surveys are available through the Soil Conservation Service. Soil testing also can be arranged through local county agricultural extension agents, State Agricultural Experiment Stations and private laboratories. The number and extent of these tests may be minimal for largely domestic sludges where the application rates are low (paragraphs 2–3.10 and 2–4), or where certain soil survey information already exists.

2–2.3 *Groundwater.* A review of existing information and/or an investigation of groundwater conditions should be made for sites where sludge is to be applied to the land at greater than crop fertilizer rates (paragraph 2–3.8). Attention should be paid to the sites' geology and soil physical properties to avoid areas underlaid by highly porous, fractured or statified formations. The extent of the evaluation should be based on the size of the project and the potential impact on groundwater. Maintaining the pH of the combined soil and sludge above 6.5 will help prevent solubilization and migration of most metal ions into the groundwater.

2–3. *General Requirements for Land Application of Sludges.*

2–3.1 *Stabilization.* Under most circumstances sludge should be stabilized (by means of chemical, physical, thermal, or biological treatment processes that result in the significant reduction of odors, volatile organics and pathogenic organics) before land application to reduce public health and to prevent nuisance odor conditions. The stabilization method most frequently used has been anaerobic digestion, but there are numerous other methods producing comparable results. Discussions involving stabilized sludge in this document are based on a product equivalent to, or better than anaerobically digested sludge.

Experience shows that consistent and effective control of odors is a major factor in the public attitudes toward sludge transport, sludge storage and land application techniques. The order conditions are closely related to anaerobic bacterial action on volatile organic matter in both the liquid and solid portions of the sludge. The degree of volatile matter reduction achieved by anaerobic digestion may vary greatly, depending on the basic digestor design and the percentage of volatile solids in the raw sludge. Well designed and carefully operated high rate anaerobic digestors can digest sludge to control odors and reduce pathogen concentrations when the sludge is digested for a least 10 days at 95° F. Such high rate digestion requires close operational control for successful per-

ard rate digestion. [Although digestion can reduce the number of influent fecal coliforms by 97 percent or more, the remaining levels of microorganisms may still have public health significance.]

Other methods to prepare sludge for land application may be used. Some examples are: composting of raw as well as digested sludge, aerobic digestion, chemical treatment (lime treatment, etc.), heat stabilization, or heat drying. In cases where stabilization is determined to be necessary, the grant applicant should show that the performance of the alternative used for preparing the sludge is equivalent to anaerobic digestion in reducing odor potential and volatile organics.

Chemical treatment of sludges may only provide temporary inhibition of odors. Incorporation of the sludge into the soil is recommended for those sludges which have odor potential (paragraph 2–3.7).

At some plants, stabilized sludge is spread on drying beds or temporarily stored in properly designed sludge lagoons. These methods decrease subsequent odor problems from sludge applied to land since additional stabilization occurs with time. Caution must be exercised, however, to ensure that there are no objectionable odors from the storage site.

2–3.2 *Additional pathogen reduction.* Under certain conditions (e.g., due to State regulatory requirements controlling public access or for projects involving hospital wastes), it may be necessary to achieve additional bacteria, parasite, and/or virus reduction or deactivation beyond that attained by stabilization. The following methods have been used:

a. Pasteurization for 30 minutes at 70° C.

b. High pH treatment, typically with lime, at a pH greater than 12 for 3 hours.

c. Long-term storage of liquid-digested sludge for at least 60 days at 20° C or 120 days at 4° C.

d. Complete composting at temperatures above 55° C as a result of oxidative bacterial action and curing in a stockpile for at least 30 days.

e. Both gamma and high energy electron ionizing radiation under various application procedures including combination treatment with thermal conditioning and oxygenation.

2–3.3 *Crops suitable for sludge application.* Crops vary in their reaction to sludge-enriched soils. Most crops benefit from the nutrients, such as nitrogen and phosphorus, and organic matter present in the sludge. However, some crop species may be adversely affected by excess heavy metals or other contaminants. Additionally, the crop may take up and accumulate certain of these trace elements, and possibly inhibit future use of the harvested materials, particularly those in the human food chain.

The degree of contaminant uptake by different crops and specific plant tissues is highly variable. For example, vegetative portions of grasses generally contain higher levels of heavy metals than the grain. Factors such as soil type, pH, moisture, and organic matter content, crop species and variety (and for cadmium, the annual and accumulative application rates) are all important and affect plant uptake rates of specific contaminants. Vegetables such as lettuce, spinach, and chard, as well as tobacco are among the highest accumulators of heavy metals such as cadmium. USDA extension and research offices and State Agricultural Experiment Stations are available for additional guidance on the selection of crops which can be satisfactorily grown on sludge enriched soils in specific geographic areas.

Forest sites and reclamation projects offer special opportunities for beneficial use of sludge to improve soil fertility and increase plant growth without significant risk to public health. In these cases it will still be necessary to comply with regulatory requirements pertaining to impacts on air, surface waters, and groundwaters, in a manner similar to that described for agricultural uses (paragraph 2–3.8).

2–3.4 *Public access* should be controlled in a positive manner where applications are above rates for agricultural use. In such instances, posted notices, and/or simple barriers, fences, remoteness of the site should be adequate.

2–3.5 *Groundwater protection.* Projects for land application of sludges will be designed so that the permanent groundwaters (groundwater which is not removed from the ground by an underdrain system or other mechanical means) in the zone of saturation (where the water is not held in the ground by capillary tension) will be protected from pollution. Consideration should be given to the extent of the project, the quality of the groundwaters, and the fact that groundwater is typically used for drinking water supply with little or no additional treatment. Also, in some areas, groundwater recharge of surface streams may be significant. Specific groundwater criteria will be developed under Pub. L. 94–580. Until such criteria are developed under Pub. L. 94–580, criteria contained in the EPA publication, "Alternative Waste Management Techniques for Best Practicable Waste Treatment," EPA 430/9–75–013 should be followed. An extract on groundwater is reproduced as Appendix II to this Bulletin.)

2–3.6 *Controlling surface water runoff.* Sound engineering practice requires the control of surface runoff that may leave the site as well as that which will enter the site from contiguous properties. Controlled release of runoff from sludge application areas and effective erosion control methods must be practiced as necessary. Consideration should also be given to materials which may leach out of the sludge. Surface water criteria are to be developed under Pub. L. 94–580.

2–3.7 *Sludge application methods.* Techniques for applying liquid sludge to the land include: tank truck, plowing, injection, or ridge and furrow spreading. Dewatered sludge, or composted sludge, may also be spread upon the land. If desired, the sludge can be incorporated into the soil by plowing, discing, or other similar methods. The use of incorporation and injection methods is encouraged as a means of improving public acceptance of sludge application by decreasing possible odor generation and unsightly deposits on crops.

Sprinkler application of digested sludge to the land is acceptable when the transport of aerosols beyond the boundaries of the application area is minimized. The use of low pressure sprinklers, short risers, or remoteness of application sites is suggested. When sprinkling at low pressures, it is good engineering practice to screen the sludge or otherwise prevent nozzle plugging.

2–3.8 *Application rates.* The sludge application rate per acre should be determined in a manner to ensure that environmental requirements are met. Nitrogenous substances usually limit annual application rates. The rate of sludge application to land should be consistent with the requirement to prevent nitrate pollution of groundwater as previously defined (paragraph 2–3.5). The information required to establish the maximum sludge application rate based on plant available nitrogen includes: (1) total and inorganic nitrogen content of sludge; (2) nitrogen, phosphorus, and potassium requirements of crop proposed; and (3) soil test for available nitrogen, phosphorus and potassium. Supplemental fertilizer, especially potassium, may be needed if optimization of crop production is desired.

As a guide, sludge application rates should provide total plant available nitrogen equivalent to the nitrogen fertilizer requirement of the crop grown, although some experience in applying 1½ to 2 times the crop's nitrogen fertilizer requirement has not lead to the development of groundwater problems. Plant available nitrogen includes that mineralized from the soil, the inorganic sludge nitrogen (ammonium and nitrate), plus a mineralization rate of 15 to 20 percent of sludge organic nitrogen (mineralizable organic nitrogen) for the first growing season following application, and three percent of the residual sludge organic nitrogen for three subsequent growing seasons. Volatilization of ammonia from surface applied sludge should be taken into account; experience has shown that about 50 percent of this nitrogen may be lost if the material is not immediately incorporated. Denitrification may also be a factor accounting for significant nitrogen losses under certain conditions.

Sludge nitrogen mineralization, volatilization, and denitrification rates may vary considerably for different climatic areas of the Nation. USDA extension and research offices, and State Agricultural Experiment Stations should be contacted to obtain specific regional information on nitrogen transformation rates, plant nitrogen, phosphorus and potassium requirements and soil test information for the local area.

An excess of certain salts, phosphorus compounds, heavy metals, persistent organic compounds, radionuclides and other materials in sludges may also limit application rates. Each prospective land application site should be assessed on an individual basis, with adequate consideration given to sludge characteristics, soil characteristics, crops to be grown, and other factors such as surface water and groundwater protection. Control of the total and annual application rates along with soil pH control and intensive monitoring programs are possible approaches which can be used to avoid problems with major contaminants of concern such as cadmium (section 2–4.2). A useful procedure for calculating the rate of sludge application to the land based on the nitrogen requirement of the crop grown and the nitrogen and metal content of the sludge is given in Appendix VIII.

Sludge is generated continuously throughout the year, but continuous field application may not be possible. A mass balance is necessary to determine the amount of sludge storage required during intervals when the sludge is not applied to the land.

2–3.9 *System operation.* The grant applicant should show the capability to manage and operate the system. Operational aspects to be described in the operation and maintenance manual include the monitoring plan, review of monitoring data, action to be taken when monitoring indicates a problem, and a commitment to use expert guidance when required. The operation and maintenance manual should specifically indicate what actions can be taken to either upgrade the site to acceptable levels or discontinue its use if it is shown to be in violation of future requirements developed by Federal or State regulatory agencies.

USDA extension and research programs are also available to help develop and provide site specific recommendations for the best agricultural practices for use of municipal sewage sludge by farmers on privately owned lands. Extracts from such guidance that has been developed for the North Central and Western states is provided in Appendix VIII. These recommendations may include suggestions to help minimize or eliminate some monitoring requirements on the farm while protecting farmland for future agricultural use, maintaining normal productivity, and assuring continued farm income.

2–3.10 *Monitoring.* The grant applicant should develop and implement a plan for adequate monitoring of each land application site where the application rate may impose a significant nitrogen loading on receiving ground or surface waters (paragraph 2–3.8), where greater rates of metals are applied than indicated in section 2–4.2 or where hazards are expected from other sludge constituents such as pathogens are persistent organics. Groundwater monitoring generally should not be required where the application rate is based upon the nitrogen fertilizer needs of the crop (paragraph 2–3.8).

It will always be necessary to know the characteristics of sludge (paragraph 2–2.1) to be applied. For new projects, it may be necessary to monitor more frequently until successful performance is assured.

The monitoring plan should be specifically designed for local conditions including site and sludge characteristics, proposed rate of application, crops to be grown, size of the project, etc. Where necessary, the plan should consider monitoring heavy metals, persistent organics, and pathogens, as well as nitrates in groundwater, surface water, sludge and soils. In addition to these recommendations and local or State requirements, additional monitoring requirements may be developed under Pub. L. 94–580.

2–3.11 *Surveillance of operation and monitoring.* The operation and monitoring data of the system must be periodically reviewed by the responsible regulatory Agency or agencies to ensure satisfactory performance. Where there is no local or state program for this purpose, an alternative independent review should be established. The grant application should show the arrangements made for surveillance.

Operational and monitoring data must be available to authorized local, State, EPA and other Federal agency representatives on request.

2–4. *Additional requirements for sludge application to agricultural lands.* In addition to the foregoing general requirements, the application of sludge to agricultural lands should be accomplished so as to ensure cropland resources are protected and harmful contaminants are not accumulated in the human food chain to create a risk to public health. Review of projects which include application of sludge to agricultural lands must be based on informed judgment and fully consider the conditions specific to a given site.

2–4.1 *Research, development and demonstration projects.* As indicated earlier (paragraph 1–6), it is the policy of EPA to encourage and, where possible, assist in the development of new or advanced wastewater treatment procedures, including sludge processing, utilization and disposal practices. Therefore, proposals involving the demonstration of new and innovative technologies for sludge management should be encouraged and expedited.

For such demonstration projects (e.g., reclamation of disturbed land with sludge), where significant resources and manpower are available for control and monitoring, the recommendations within this Bulletin may be exceeded in an effort to investigate new approaches for sludge management. An environmental assessment should verify that this is the case for particular projects. Some demonstration projects have the capability (including in-house effort and consultant assistance) to intensively monitor and evaluate the project as it develops. Work on these projects should be closely coordinated with EPA, USDA and FDA, as well as State and local authorities, to ensure satisfactory results including acceptable crop quality if crops grown are to be marketed (as described under section 2–4.2 B). Control criteria for these projects should be subject to continuing modification as information is developed. For these research, development and demonstration projects, the Agency review should assure that adequate resources are made available for the evaluation of project performance, arrangements are established for surveillance of the project, and review of project data is arranged for EPA and other interested agencies such as FDA, USDA, State Agriculture and Health Departments.

2–4.2 *Protection of food products and agricultural lands.* Regulations exist to control the level of mercury and persistent organic chemicals, such as pesticides and polychlorinated biphenyls (PCB's), in certain components of the human food chain. However, similar regulations have not been established for all contaminants in foods. When other regulations are implemented, those sludge land application projects involving the production of crops in the human food chain will have to produce crops that conform to these regulations. Contaminants of particular concern in municipal sludge as related to the production of human food and animal feed crops are cadmium and lead, as well as mercury, arsenic, selenium, and persistent organics such as pesticides and PCB's.

A wide variety of site specific conditions and management variables can affect the level of heavy metals entering crops. These variables have been and continue to be examined by many groups within FDA, USDA and State agencies. It is therefore recommended that projects conform to limitations for crop quality (human food or animal feed) established by these agencies.

The available information concerning the benefits and potential impacts of applying municipal sludge to agricultural land has been reviewed and summarized elsewhere. This available information indicates that many municipal sewage sludges can be applied to agricultural land when good agricultural management practices are employed. Upper limits on annual heavy metals loadings were suggested by various sources, based upon the currently available data base, with the anticipation that modifications will be made in time based upon additional research.

As discussed in section 2–1 elsewhere, regulations, criteria and guidelines being developed under authorities of Pub. L. 92–500, TSCA, RCRA and other recent environmental legislation may impact the future acceptance of various land application practices in various ways. Pretreatment requirements and solid waste disposal and utilization criteria and guidelines currently under development will provide numerical limitations aimed at reducing the levels of pollutants discharged into the environment, including allowable cadmium additions to agricultural soils through solid waste (including municipal sludge) application. As a result of progressively imposing more stringent pretreatment regulations on industrial wastes discharged into municipal systems, there should be a corresponding reduction of sludge borne contaminants.

Until regulatory requirements are established, the following guidance will allow for the application of most sludges to agricultural land at crop nitrogen fertilizer rates (paragraph 2–3.8).

A. *Privately owned agricultural lands.* The following guidance is suggested for application of municipal sludge to privately owned and managed cropland. These recommendations should protect private farmlands for future agricultural use, maintain their normal productivity, and assure continued farm income while minimizing monitoring requirements to those normally used for assuring good soil management:

(1) *Annual cadmium loadings.* The maximum annual loading of cadmium that should not be exceeded when applying sludge to agricultural land depends upon site conditions and management practices employed. The annual cadmium loadings that have been used successfully range from less than 1 kg/ha up to 2 kg/ha. While lower cadmium application rates are preferable, in those cases where good site conditions (i.e., high pH soils) and good management practices (i.e., soil pH control, monitoring, selecting crop species and varieties that do not readily take up heavy metals, etc.) prevail, annual loadings of 2 kg/ha have been employed. Because of the concern over potential health effects from increased ingestion of cadmium in foods, it is the intent of EPA to move toward minimizing cadmium additions to cropland. Movement toward lower cadmium additions will be reflected in the criteria for land application of solid wastes to be developed and issued under the Resource Conservation and Recovery Act of 1976 (Pub. L. 94–580).

(ii) *Soil/sludge pH control.* The pH of the soil/sludge mixture should be controlled to limit heavy metal uptake by plants. A pH of 6.5 or greater will minimize uptake of most heavy metals by most crops. As soil pH drops, heavy metal solubility in soil and availability to crops is increased. Under some site specific conditions (as in many strip-mined areas), availability of metals present in the soil before sludge application can acually be reduced by the application of sludge, because sludge addition in itself may tend to raise soil pH of a highly acid soil and because binding of the heavy metals into organic complexes may occur. But it is rare that the final pH will be 6.5 or greater. Therefore, consideration should be given to including supplemental liming. Additional guidance on tailoring soil/sludge pH to specific cropping systems may be gained from local agricultural extension agents, State Agricultural Experiment Stations, USDA, etc. The pH level maintained should be designed to meet the intent of limiting heavy metal solubility in soil and possible movement of heavy metals into groundwater or into crops by uptake.

(iii) *Total cumulative metal loadings.* It has been demonstrated that the following total cumulative metal loadings from applying municipal sludge to agricultural land have not led to observed problems (when soil pH is controlled):

Metal	Soil cation exchange capacity (milliequivalent per 100 g)*		
	0–5	5–15	>15
	Amount of metal (kilogram per hectare)		
Pb	500	1,000	2,000
Zn	250	500	1,000
Cu	125	250	500
Ni	50	100	200
Cd	5	10	20

* Cation exchange capacity (CEC) determined on soil prior to sludge application by pH 7 ammonium acetate procedure.

NOTE.—It is recognized that soil CEC is not the only factor important in setting levels of metal additions to soil. While its use as an index is recommended (providing that soil pH is also controlled) other factors such as soil colloidal, organic and sesquioxide contents may be equally or more important in limiting metal availability.

(iv) *Calculating sludge application rates.* A useful procedure for calculating the rate of sludge applications to the land (paragraph 2–3.8) based on the nitrogen and metal content of the sludge is given in Appendix VIII.

In addition to the above, the following measures are also suggested as possible means

to overcome problems of dealing with highly contaminated sludges:

(v) *Ratio of cadmium to zinc in sludges.* It is suggested that in naturally acid soils the ratio of cadmium to zinc in sludge should be considered in addition to total annual rates of application. An important premise of this concept is that with poor management (e.g., mproper crop selection and low soil pH), high enough zinc concentrations in soil to kill plants would result before cadmium could accumulate to levels in foods considered hazardous to animals and humans. The preferred practice suggested by USDA and some researchers is to apply sludges (to naturally acid soils) with a Cd/Zn $\leq$0.015 to these privately owned croplands.

(vi) *Pretreatment programs.* Implementation of a local pretreatment program aimed at reducing metals discharged into the municipal system may help overcome the problems that must be faced when considering the application of highly contaminated sludges to cropland.

(vii) *Other technology.* Use of other technology or management aimed at minimizing impact upon soil, groundwater and surface water, crops and/or the human food chain such as the use of selective crop species and varieties that minimize contaminant uptake or application of sludge at less than crop nitrogen needs. In any case, an expanded monitoring program should be implemented to assure control of pollutant migration and quality assurance of the project. The monitoring plan should be capable of noting trends in crop productivity decline, contaminant uptake in final marketed products, groundwater and surface water quality.

B. *Publicly controlled agricultural lands.* When municipal sludge is applied to publicly controlled (owned or leased) land and crops are grown and harvested, higher rates of application may be used if: (1) the use of these rates is acceptable to the responsible regulatory agency(s), and (2) a detailed monitoring program is established to assure acceptable crop quality and to provide close surveillance of groundwater, surface water and soils. If metal additions exceed those recommended in (A) above, priority consideration should be given to growing crops that are not directly consumed by humans.

If human foods or animal feeds are grown and harvested, higher rates of sludge application may be acceptable if resulting levels of cadmium in the crops or meats marketed are comparable to those levels present in similar crops or meats produced locally or as established by FDA or other responsible regulatory agencies. For example, strip mined land which has been reclaimed through high rate sludge application may be used for producing animal feeds; however, organs (e.g., kidneys and livers) which may accumulate cadmium in animals fed such feeds should not be sold for human consumption unless their cadmium levels are comparable to those found in animals produced locally.

C. *Sites previously dedicated for disposal.* The dedication of publicly controlled or owned land for high rate application (including trenching) to allow maximum utilization of the "dedicated site" for the disposal of municipal sludge has been practiced. This is a particularly useful practice for sludges with high contamination levels or where very high loadings of sludge are desired. Project monitoring is generally established to assure close surveillance of groundwater and surface water as discussed under monitoring of landfills (paragraph 3–1.7).

In cases where crops are grown following the disposal of municipal sludge to such "dedicated sites," the crops are generally not harvested for use as human foods or animal feeds. However, if human foods or animal feed crops are grown and harvested for further use, the marketing of crops and meats produced should be handled as in (B) above.

In all cases where the application of municipal sludge to agricultural lands and production of human foods or animal feeds is proposed (whether on private land, publicly controlled land, or "dedicated sites"), the project should be coordinated at the State and local levels to include the approval of appropriate regulatory agencies.

Experience has shown that under special conditions specific organisms may survive in the soil for extended periods of time. Therefore, unless pathogen reduction by methods such as those listed in 2–3.3, or other suitable measures have been employed to minimize human exposure to such organisms in sludge, additional precautions should be taken to assure that the impact of pathogenic bacteria, parasites and viruses in sludge used for certain agricultural purposes, will be minimal. Measures that have been used include the following:

(a) Sludge-treated land should not be used for growing human food crops to be eaten raw if the edible portion of the plant is in direct contact with the sludge or soils receiving sludges until one year after final sludge application or longer if there are positive indications of viable *Ascaris* ova. The available data base indicates that *Ascaris* ova may remain viable in soil for three years or longer.

(b) Use of application methods to prevent direct contact of the sludge with the portion of the crop to be consumed.

(c) Application to pasture land should be done in a manner that avoids contact between the freshly applied sludge and grazing animals raised mainly for milk. Forage and pasture crops should not be consumed by these animals when physically contaminated by freshly applied sludge. Particular attention should be given to avoiding problems with lead, cadmium, and PCB's contaminating the milk through direct ingestion of contaminated sludge.

Although crop quality standards have not been established to date for many contaminants, efforts are underway by FDA to develop such limitations. FDA has, however, provided their recommendations to limit the applications of sludge to land used to grow human or animal foods (Appendix IX).

2–4.3 *Project review.* When the project includes application to agricultural land, especially if it involves high application rates (paragraph 2–3.8), or sludges with a high concentration of contaminants (paragraphs 2–2.1 and 2–4.2 and Appendix VII), it may be necessary for the Regional Administrator to consult with USDA and FDA as part of the review process. This is especially true for large agricultural projects. The review must ensure that all applicable State and Federal regulatory requirements are met. Technical assistance during preparation of the grant application and facility plan development is available from these same agencies as well as the appropriate State offices.

2–4.4 *Additional monitoring requirements.* In addition to the monitoring requirements presented in 2–3.10, baseline sludge analysis should be conducted to serve as a sound basis for setting of application rates, selection of crops and determining other monitoring requirements. Sludges should be characterized in terms of the range of their contaminant concentration including heavy metals (such as cadmium, zinc, molybdenum, copper, nickel, lead, mercury, arsenic and selenium) and persistent organic compounds (such as chlorinated pesticides and PCB's). The sludges should also be analyzed for parameters (such as pH, nitrogen, phosphorus, potassium, and organic content, and possibly calcium and magnesium).

Where products are grown for human consumption on soils, especially to which greater levels of metals or organics have been applied than in this suggested guidance, crop monitoring may be necessary for suspected problem metals, organics, as well as pathogens and parasites.

Records including analyses should be kept by the sludge generating municipality that include sludge quality, locations receiving sludge, annual and total sludge application rates, crops grown and soil pH.

The monitoring plan should be specifically designed for local site conditions and take into account applicable local, State and Federal regulatory requirements by including consideration of sludges, soils, crops, surface water and groundwater quality.

2–4.5 *Technical assistance and use of other sludges.* In recognition of the fact that the guidance in the preceding paragraphs is based on limited information, technical assistance for planning and designing land application projects is available from several sources. These include EPA Headquarters and National Environmental Research Centers (especially the Municipal Environmental Research Laboratory in Cincinnati, Ohio), FDA, USDA extension and research elements, State Agricultural Experiment Stations, and other sources (Appendix X).

In addition to municipal sludge, other sludges (e.g., sludges produced by treatment of food processing and brewery wastes) may also be acceptable for land application under carefully defined and controlled practices. Because of the potential benefits to agriculture from sludge application carried out under sound agricultural management conditions, full exploration of this and other beneficial use options is encouraged.

Chapter III

Sludge Disposal Methods

3–1. *Sanitary Landfill.*

3–1.1 *General.* Sanitary landfill of sludge, either separately or along with municipal solid waste, is acceptable when supported by an environmental assessment.

3–1.2 *Landfill procedures.* A sanitary landfill accepting sludge should be designed and operated in accordance with EPA Guidelines for Land Disposal of Solid Wastes (40 CFR 241 Appendix III). Although it does not directly address landfilling of sewage sludge, specific guidance for the proper design and operation of a sanitary landfill are included in EPA's publication, "Sanitary Landfill Design and Operation" (SW–65ts). Each site should also comply with appropriate criteria and guidelines being developed under Pub. L. 94–580 for landfilling of sewage sludge. Proposals involving research, development and demonstration of new and innovative landfill technologies should be encouraged and expedited (as discussed for land application technologies in paragraph 2–4.1).

3–1.3 *Odor Control.* The sanitary landfill must be operated so as to prevent nuisance odors. Normally, the sludge must be stabilized as described for land application (paragraph 2–3.1).

3–1.4 *Precautions for protection of public health.* Sludge stabilization and the daily soil cover are generally adequate protection from direct health hazards. Additional precautions may be necessary if the public has unrestricted access to the landfill site.

3–1.5 *Groundwater protection.* The groundwater underlying the sanitary landfill accepting sludge must be protected and the sanitary landfill must meet applicable State

groundwater protection requirements. A geohydrologic assessment should be undertaken to determine the adequacy of the site prior to use as a sludge landfill.

3–1.6 *Operation.* If a sanitary landfill accepting sludge is not operated by the wastewater treatment authority, a binding agreement should be required between the wastewater treatment authority and the operator of the sanitary landfill. Such a binding agreement should include necessary assurances of compliance with the requirements and recommendations of the EPA guidelines (40 CFR 241 Appendix III) and criteria being developed under Pub. L. 94–580.

3–1.7 *Monitoring.* A plan should be developed and implemented to provide for adequate monitoring for each sanitary landfill accepting sludge. This plan should be specifically designed to protect groundwater and to ensure protection of surface waters, in the following manner:

a. Groundwater observation wells tested for heavy metals, persistent organics, pathogens, and nitrates;

b. Where the surface water could be affected by direct runoff or leachate from the landfill receiving sludge, surface water monitoring tested for indicators (such as chemical oxygen demands and total dissolved solids). Additional testing may be necessary if it is determined that a poor quality leachate is entering surface waters.

3–2. *Incineration.*

3–2.1 *General.* Sludge incineration and disposal of the resulting ash is an environmentally acceptable method for the disposal of sludge when the environmental assessment shows it to be appropriate. Incineration alone is a volume reduction method rather than ultimate disposal. Volume reduction, however, can be an important consideration where land availability is a problem. After incineration, ash, either dry or in scrubber water, remains to be disposed of to the land. Ash disposal must be designed to protect groundwater, to minimize dust production, and to ensure protection of surface waters. Each site should comply with the criteria being developed under Pub. L. 94–580. Proposals involving research, development and demonstration of new and innovative incineration technologies should be encouraged and expedited (as discussed for land application technologies in paragraph 2–4.1).

Due to the increasing costs and limited availability of energy resources, acceptability and viability of incineration processes is dependent on the ability to recover or reclaim energy from the process. Data available to date indicate that fuel requirements of incineration processes can be reduced by available energy recovery technologies. In some cases, energy recovery can possibly even offset a substantial portion of the energy requirements for the entire wastewater treatment plant. While the basic concepts of energy recovery from incineration of wastes are not new, the application of these concepts to wastewater treatment and sludge management facilities generally require special design considerations. New facilities can be designed from the outset to incorporate the necessary equipment to utilize energy recovered from incineration processes. In existing plants, retrofitting of equipment capable of using recovered energy will be necessary and could be considered to facilitate incineration where cost-effective. When energy aspects are addressed in incineration system designs, they should evaluate future as well as current energy conservation and recovery considerations.

3–2.2 *Industrial wastewaters.* When introduced into a municipal wastewater treatment works that practices sludge incineration, industrial wastewaters should be pretreated to reduce to a minimum the amounts of mercury, persistent organics, and radioactive materials. In developing pretreatment programs, special attention must be given to the disposal of sludge created or materials removed during the pretreatment process. Disposal of these materials must be in an environmentally sound manner.

3–2.3 *Air Quality.* The emissions from the sludge incinerator must not result in violation of ambient air quality standards and must meet the EPA air pollution emission standards of performance contained in the New Source Performance Standards for Sludge Incinerators (40 CFR 60.15, Appendix IV). Sewage sludge incinerator discharges into the atmosphere are not to exceed particulate matter at a rate in excess of 0.65 g/kg dry sludge input (1.30 lb/ton dry sludge input) and gases are not to exhibit 20 percent opacity or greater (except where the presence of uncombined water is the only reason for failure to meet the opacity requirement). These emission limits are based on a venturi scrubber, but any similar equipment which meets the standard is acceptable. Sludge incineration is known to vaporize any mercury present in the incoming sludge. EPA has published Amendments to National Emission Standards which do limit mercury emissions from the incineration and drying of wastewater treatment plant sludges to a maximum of 3200 grams per 24 hour period (40 CFR 61.52, included as Appendix V of this document).

3–2.4 *Specific emissions.* Tests have shown that sludge incinerator emissions can contain volatilized mercury as well as persistent organic compounds, such as polychlorinated biphenyls, and particulates containing trace amounts of metals such as lead and cadmium. The effect of these compounds which are emitted from the incinerator must be assessed and the sludge should be tested to determine the quantities of compounds present. If the PCB's exceed 25 mg/kg dry sludge, then special measures should be taken to ensure at least 95 percent destruction of persistent organic compounds in incineration. This could consist of testing the performance of an incinerator design to verify satisfactory performance or making allowances in the design. Increased temperature and residence time increase the assurance of destruction.

Regulations being developed under the Toxic Substances Control Act (Pub. L. 94–469) and the Resource Conservation and Recovery Act (Pub. L. 94–580) should be consulted regarding current standards for disposal of PCB containing substances. Proposed rules on PCB's disposal under TSCA (Pub. L. 94–469) were published in the FEDERAL REGISTER on May 24, 1977. Incineration conditions specified therein for materials (PCB mixtures, waste materials, and sludges) that contain 500 ppm or greater of PCB chemical substances (on a dry weight basis) are 1200° C (100° C) for a two second dwell time. While municipal sewage sludges seldom have contamination levels over 500 ppm, final rules promulgated under Pub. L. 94–469 and those being developed under Pub. L. 94–580 should be consulted regarding the disposal of PCB containing municipal sewage sludge.

3–2.5 *Monitoring.* A plan must be developed and implemented to provide for adequate monitoring of each sludge incinerator. The stack gas emissions from sludge incinerators must be monitored to ensure compliance with 40 CFR 60.15 (Appendix IV). In addition, mercury, either in the sludge or in stack gas emissions, must be periodically tested to demonstrate compliance with 40 CFR 61.5 (Appendix V). Wastewater from industrial users must be monitored if it is determined that such users will be a significant source of mercury in the municipal sludge. Additional monitoring for organic pesticides, PCB's or heavy metals other than mercury, may be necessary for specific projects.

3–3. *Ocean Disposal.*

3–3.1 *General.* Although approximately 15 percent of the current sludge volume produced in municipal treatment plants is now disposed of into the oceans; the practice of ocean dumping is now being done only under interim ocean dumping permits, because the sludges do not meet existing ocean dumping criteria. Sludge dumping is scheduled to be phased out by the end of 1981.

The Federal Water Pollution Control Act as amended (Pub. L. 92–500), and the Marine Protection, Research and Sanctuaries Act of 1972 (Pub. L. 92–532) have established a Federal program of marine pollution abatement and control. EPA has issued regulations and criteria (40 CFR 220–227, Appendix VI) to govern the disposal of wastes to the marine environment. EPA controls such disposal by a system of permits for the discharge, transportation, and dumping of all waste materials into the marine environment, except for dredged material which is controlled by the Corps of Engineers, subject to EPA Criteria. Ocean discharge of sludge through outfalls is regulated by EPA under the National Pollutant Discharge Elimination System (NPDES).

3–3.2 *Permits.* Information available to EPA from permit applications to date indicates that those sludges currently being dumped exceed the criteria and are therefore being dumped under interim permits. One of the conditions of these interim permits is the requirement for an implementation plan to either reduce the toxicity of the materials to meet the criteria or find an alternative method of disposal. Interim permits are granted for one year only and the issuance of new interim permits is based on the progress demonstrated by the permittee on this implementation plan.

3–3.3 *Dumping sites.* Ocean disposal of sewage sludge is strictly controlled by EPA. Currently EPA will approve only existing dumping sites presently in use for the disposal of particular kinds of waste, unless there is extremely strong evidence in favor of approval of a new location.

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